Gesture Controlled Robotic System using Monochromatic Camera and Array of IR-Sensors

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ABSTRACT

Technology is a never ending process. To be able to design a product using the current technology that will be beneficial to the lives of others is a huge contribution to the community. The project area is in robotics. This abstract presents the design and implementation of a low cost but yet flexible and robust 3D gesture controlled Robotic Arm. Imagine things that are done in a computer just like in real life. Natural movements replaced all those clicks, taps, drags and drops. Hand gesture recognition has been a very active research topic in recent years with the goal of interpreting human gestures via mathematical algorithms and with motivating applications such as robot control, and sign language interpretation. Motivates for this work is a robot navigation problem, in which controlling a robot by hand pose signs given by a human. In this project designing a robotic arm that can be moved upward, downward, left and right depending on human hand gestures. The Robotic Arm is mounted over a movable platform. The human gestures will be captured via 3D sensor. After that images will be processed to recognize the gestures and take action accordingly. This processing is done in a PC/Laptop with a GUI. The information (in the form of Euler angles row, pitch and yaw) is then transmitted to the robotic arm section using a wireless module. The embedded system on the robotic arm computes the pulse width of the PWM signals for the servos that are required to move the arm to the position indicated by the Euler angles. The Pitch and Yaw angles to control 5 servos mounted perpendicularly.

3D SENSOR: Using two monochromatic IR cameras with three infrared LEDs, the device observes a roughly hemispherical area, to a distance of about 1 meter .Synthesizing 3D position data by comparing the 2D frames generated by the two cameras.

Keywords— Pulse width modulation, 3D gesture controlled, Robotic Arm.

I. INTRODUCTION

Vision based automatic hand gesture recognition has been a very active research topic in recent years with motivating applications such as human computer interaction (HCI), robot control, and sign language interpretation. The general problem is quite challenging due a number of issues including the complicated nature of static and dynamic hand gestures, complex backgrounds, and occlusions. Attacking the problem in its generality requires elaborate algorithms requiring intensive computer resources. In this project design a robotic arm that can move depending on human hand gestures. The human gestures will be captured via 3D sensor. After that images will be processed to recognize the gestures and take action accordingly. Even though the technology of synthesizing hand gesture exists using flex sensor and mems sensor the peculiarity of this system is that trying to implement this technology without the use of wearable sensors. Instead by using 3D sensors thus our hand becomes free of sensors. The main application of this could be found at the car manufacturing industries, and
also medical field for doing virtual surgeries. The application can be extended for use in similar virtual applications. I sincerely hope to come up with a useful product for the scientific world.

II. RELATED WORKS

A. MEMS Accelerometer

Fig. 1. Previous Work, Mems wearable Gesture glove

An accelerometer is a device that measures proper acceleration (g-force). Proper acceleration is not the same as coordinate acceleration (rate of change of velocity). For example, an accelerometer at rest on the surface of the Earth will measure an acceleration \( g = 9.81 \text{ m/s}^2 \) straight upwards. By contrast, accelerometers in free fall orbiting and accelerating due to the gravity of Earth will measure zero. Conceptually, an accelerometer behaves as a damped mass on a spring. When the accelerometer experiences an acceleration, the mass is displaced to the point that the spring is able to accelerate the mass at the same rate as the casing. The displacement is then measured to give the acceleration.

- Not accurate
- Can only express simple gestures
- Proteus 8 Professional (simulations)
- Very bulky wearable hardware

III. SCOPE OF THE WORK

The main application of this could be found at
- Car manufacturing Industries (automotive in dustries)[7]
- Military application (Bomb disposal)[5]
- Medical field[6]

Because of the advantages like
- Reacts fast to changes
- Reduces complexity of planning
- Reduces time taken to position the arm
- And the most important advantage: no wearable sensors

IV. METHODOLOGY

A. Proposed System

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In this project designing a robotic arm that can be moved upward, downward, left and right depending on human hand gestures. Also introducing gripper motion through hand gestures

1) Technology Used: This field includes methods for acquiring, processing, analyzing, and understanding images and, in general, high-dimensional data from the real world in order to produce numerical or symbolic information, e.g., in the forms of decisions. A theme in the development of this field has been to duplicate the abilities of human vision by electronically perceiving and understanding an
image. This image understanding can be seen as the disentangling of symbolic information from image data using models constructed with the aid of geometry, physics, statistics, and learning theory. Computer vision has also been described as the enterprise of automating and integrating a wide range of processes and representations for vision perception. As a scientific discipline, computer vision is concerned with the theory behind artificial systems that extract information from images. The image data can take many forms, such as video sequences, views from multiple cameras, or multi-dimensional data from a medical scanner. As a technological discipline, computer vision seeks to apply its theories and models to the construction of computer vision systems. Sub-domains of computer vision include scene reconstruction, event detection, video tracking, object recognition, learning, indexing, motion estimation, and image restoration.

Areas of artificial intelligence deal with autonomous planning or deliberation for robotic systems to navigate through an environment. A detailed understanding of these environments is required to navigate through them. Information about the environment could be provided by a computer vision system, acting as a vision sensor and providing high-level information about the environment and the robot. [3] Artificial intelligence and computer vision share other topics such as pattern recognition and learning techniques. Consequently, computer vision is sometimes seen as a part of the artificial intelligence field or the computer science field in general.

2) Methods Of Gesture Synthesis: The ability to track a person's movements and determine what gestures they may be performing can be achieved through various tools. [1] Although there is a large amount of research done in image/video based gesture recognition, there is some variation within the tools and environments used between implementations.

![Image of gesture synthesis methods](image)

Fig. 4. Algorithms

Different ways of tracking and analyzing gestures exist, and some basic layout is given in the diagram above. For example, [2] volumetric models convey the necessary information required for an elaborate analysis, however they prove to be very intensive in terms of computational power and require further technological developments in order to be implemented for real-time analysis. On the other hand, appearance-based models are easier to process but usually lack the generality required for Human-Computer Interaction. The proposed model consists of two sections.
The last filtered out shown in the output console for thumb gesture represent as Thumb direction: 90. This 90 indicates the degrees of gripper servo and now the state of the gripper is in open position. When the Thumb direction value decreases the gripper position tends to closed position.

For gripper action most suitable gesture will be the thumb movement as shown in the figure 5.5. While opening the thumb, skeletal algorithm model gives an out as x,y,z axis. So by filtering the data as per to our application, gripper servo can be controlled. From PC, the datas are send to AT-MEGA328 and appropriate PWMs are generated, in this case PWM for gripper servo. Here Thumb- open gives an action of Gripper-open vice versa.

V. SIMULATION AND ANALYSIS

- Simulation software used here is Proteus 8 Professional. Microcontroller program is loaded into this software and obtained PWMs for servo motors. PWMs are made by using functions in ATMEGA328, here header file used is Servo.h.
- To build and tested with 5 degrees of freedom robotic arm that made from acrylic sheet, with respected to prototype model
- Technology helpful fields: In medical field for doing virtual surgeries. Thus efficient doctors can control surgeries being at different places wirelessly their hand free of sensors. The missions or activities in a space craft can be
controlled by the robotic arm. The exertions of a nuclear power plant where human reach is impossible can be managed by the arm.

Fig. 11. GUI in Visual studio

With help of Visual studio software an appropriate GUI is developed. Each gesture motion is captured and saved. These captured points can be modify using the sliders. A tool box is given for run, clear, open, save and reset. By using these scripting tools, appropriate run, clear, open, save and reset can be done. Also a delay selection option given for smooth working of robotic arm.

Table consists of motion details such as each degrees of freedom of servo motors. By each input through sliders values are automatically listed in the table. These values can be manipulated according to the user specification.

Fig. 12. Captured gesture value

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Fig. 13. Graph plotted from captured value

Sudden change in degrees of servo motor causes a small spike. This spike is filtered in PID action of servo motor. The entire robotic system is moved by a four wheeled base. The required datas from GUI to robotic arm is sent through a wireless module zigbee series 1. The entire system requires a power supply of 5V 5A.

Fig. 14. microcontroller circuit, zigbee s1, motordriver
VI. HARDWARE

A. Prototype of Robotic arm

Fig. 15. Hardware- Prototype of Robotic arm

B. Prototype of Robot Gripper

Fig. 16. Hardware- Prototype of Robot Gripper

VII. CONCLUSION

In this project designing of a robotic arm that can be moved depending upon human hand gestures is presented. The human gestures will be captured via 3D sensor. After that frames will be processed to recognize the gestures and take action accordingly. The project is found to be useful in many areas as per study. Compared to MEMs accelerometer method, the proposed system have more accuracy and can capture complex gestures. Therefore, the proposed system is a competitive alternative for practical applications where accuracy and more complex hand gestures are demanded, such as robust systems, with reduced size, complexity and high efficiency. The simulation and practical output results prove their functionality and confirms the better gesture controlled system.

REFERENCES